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Internal-Combustion Piston Driving Apparatus

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Specification

1. Title of the invention

Internal-Combustion Piston Driving Apparatus

2. Claims

1. An internal-combustion piston driving apparatus, which comprises a housing with an opening and a combustion chamber defined by a piston sliding within a cylinder adjacent to the opening of the housing, and which comprises a device for filling air and fuel into the combustion chamber and a device for igniting fuel-air mixture filled in said combustion chamber, wherein the piston is driven by expanded combustion gas,

wherein the apparatus comprising a device for heating fuel or fuel-air mixture.

2. The internal-combustion piston driving apparatus as claimed in Claim 1, wherein heating of the fuel or fuel-air mixture is controlled based on a device for detecting temperature and the detected temperature.

3. Detailed description of the invention

[Application field of the invention]

The present invention relates to a fuel heating device of a piston driving apparatus, such as a nailer that drives a piston by means of combustion energy.

[Background of the invention]

US Pat. No. 4,403,722 may be cited as a prior art of the internal-combustion piston driving apparatus such as a nailer utilizing gas combustion. An example of this invention includes liquefied fuel such as butane filled in a pressurized tank for adapting the nailer to be portable. However, when the environmental temperature is such low as the internal temperature of combustion chamber is under the boiling point of fuel, the fuel does not evaporate, i.e. the fuel-air mixture assuring ignition cannot be supplied stably, therefore the nailer fails in working.

Considering that such type of nailer is used not only indoors but also often outdoors, the nailer should be improved so that it can be operated simply at a low environmental temperature in the same way as at a normal temperature.

[Object of the invention]

An object of the present invention is to solve the above problem of the prior art and improve such type of piston driving apparatus in its operability at a low environmental temperature.

[Outline of the invention]

The present inventors have paid attention to the fact that vapor pressure of liquid fuel increases as temperature rises, and gave thorough consideration to a

combination of a device for heating fuel or fuel-air mixture and a device for detecting temperature, so that an ignitable fuel-air mixture always can be fed into the combustion chamber even when the environmental temperature is low.

[Example of the invention]

An example of the gas combustion piston driving apparatus according to the present invention, specifically e.g. a structure of nailer, will be described with referring to Figs. 1, 2, 3, 4, 5, 6 and 7.

In Fig. 1, symbol 1 is a housing having an opening therein; symbol 46 being a cylinder cover fixed on the opening side of said housing 1; symbol 2 being a cylinder which is slidable within a space surrounded by the cylinder cover 46 and the housing 1; symbol 3 being a piston which is slidable within said cylinder 2; and symbol 4 being a guide fixed on the side opposite said cylinder cover 46 of the housing 1, respectively. Inside said guide 4, a rod 5 fixedly attached to said piston 3 is disposed slidably so as to drive a nail (not shown in the figure), and, by the side of the guide 4, a nail feed unit 6 for inserting nails into the guide 4 is mounted.

At the part said piston 3 slides against said cylinder 2, an O-ring 14 is mounted to make airtight, so that a combustion chamber 7 is formed by a closed space

surrounded by the housing 1, the cylinder 2 and the piston 3, and the combustion chamber 7 is further divided into 7a-7d by lattices 15a-15c mounted in the combustion chamber 7. Symbols 44a-44d are openings distributed over the whole of lattices 15a-15c.

Symbol 16 is an ignition controller for generating a high voltage on an ignition plug 18, positioned inside the combustion chamber 7, by means of piezoelectric element etc. to ignite fuel. Symbol 34 is a fuel cylinder contained in the housing 1, and 35 is a fuel piston that slides within the fuel cylinder 34. Symbol 9 is a fuel chamber defined by the fuel cylinder 34 and the fuel piston 35, which is filled with liquefied fuel gas such as butane etc. and compressed by a pressure spring 30 mounted on the side opposite the fuel piston 35, so that the liquefied fuel gas is kept in a liquid phase. Symbol 36 is a metering cylinder in which metering bulb 37 is provided slidably. Symbol 38 is a metering chamber enclosed by the metering bulb 37.

Symbol 17 is a temperature controller for heating the metering chamber 38. A structure of the temperature controller 17 is shown in Fig. 6. A resistor 42 disposed adjacent to the metering chamber 38 is heated by the power source 41, and thereby the liquefied fuel in the metering chamber 38 is heated. When the temperature of the

liquefied fuel rises, the resistance of a thermal element 40, which is also disposed adjacent to the metering chamber 38, increases and it causes the heating power of the resistor 42 to be lowered, i.e. the heating power to the liquefied fuel is adjusted to be controlled. Symbol 10 is a carburetor defined by a nozzle 39, which is disposed adjacent to the housing 1 and the combustion chamber 7.

Symbol 31 is a first path connecting the fuel chamber 9 and the metering cylinder 36. Symbol 32 is a second path connecting the metering cylinder 36 and the carburetor 10. The relationship between the positions of the first path 31 and the second path 32 is conditioned as follows. When the metering bulb 37 is at the top dead point as in Fig. 6, the first path 31 is communicated with the metering chamber 38 and the second path 32 is closed to the metering chamber 38. When the metering bulb 37 is at the bottom dead point as in Fig. 7, the metering chamber 38 is communicated with the carburetor 10 through the second path 32.

Symbol 20 is a vent sleeve, disposed on the wall surface of the combustion chamber 7, which slides along the circumference of the housing 1 outside the combustion chamber 7 to close or open an exhaust port 24 and a scavenging port 25, both ports being communicated with the outside. Symbol 33 is a passage, formed on the vent sleeve

20, for connecting the scavenging port 25 to the outside when the vent sleeve 20 slid, as in Fig. 5.

Symbol 26 is a piston stopper, formed on the cylinder 2 at an edge on the side of lattices 15, which is formed larger in diameter than the other portion of the cylinder 2, along which the piston 3 slides, for resting the piston 3 at the side of lattices 15 by the elasticity of O-ring 14, when said piston 3 came to the lattice 15 side and said O-ring 14 came to the piston stopper 26.

A cylinder damper 19 is provided at the opening of said combustion chamber 7 on the side of piston 3, for preventing the piston 3 and the cylinder 2 from moving toward the side of lattices 15. Furthermore, a piston damper 27 is mounted on the cylinder cover 46 at the side of the guide 4, for defining the driving stroke of the piston 3.

Symbol 8 is a pressure accumulating chamber, which is enclosed by the housing 1, the cylinder 2, the cylinder cover 46 and the vent sleeve 20. Symbol 11 is a pressure accumulating port, formed on the wall surface at a position extended from the bottom dead point of the cylinder 2 on the driving side, for connecting the pressure accumulating chamber 8 and the cylinder 2. Symbol 21 is a pressure accumulating valve for blocking the flow from the pressure accumulating chamber 8 to the cylinder 2.

Symbol 12 is an inlet port, formed at a position extended from the bottom dead point of the piston 3, for connecting the cylinder 2 and the fresh-air outside. Symbol 22 is an inlet valve for blocking the flow from the cylinder 2 side to the fresh-air side at the inlet port 12. Symbol 28 is a pressure detecting chamber, which is enclosed by a control sleeve 45 mounted on the outer wall of the cylinder 2 and the housing 1. And, symbol 13 is a controlling port, disposed on the wall surface of the cylinder 2, which is communicating with the pressure detecting chamber 28.

Symbol 43 is a pressure reducing path which is communicating with the air outside at the circumference of the cylinder 2 on the side of lattices 15. Symbol 23 is a pressure reducing valve for blocking the flow from the fresh-air side to the cylinder 2 side at the pressure reducing path 43. Outside the cylinder 2, a cylinder spring 29 is mounted to urge the cylinder toward the side of lattices 15, and the pressure reducing path 43 is closed or opened at the side of cylinder 2 according to the positions of cylinder 2 and the cylinder damper 19.

Now, the appearance of the nailer before operation is shown in Fig. 1. The piston 3 is resting on the piston stopper 26. Both the exhaust port 24 and the scavenging port 25 on the wall surface of the combustion chamber 7 are closed by the vent sleeve 20 as in Fig. 1. The

pressure reducing path 43 is closed at the side of cylinder 2. The metering bulb 37 is positioned at its bottom dead point as shown in Fig. 7, and the inside of the metering chamber 38 is filled with liquefied fuel gas. The liquefied fuel gas in the metering chamber 38 is heated by the temperature controller 17.

Next, the operation of this nailer will be described. The vent sleeve 20 is slid to the position as in Fig. 4 to close both the exhaust port 24 and the scavenging port 25 of the combustion chamber 7, and then the metering bulb 37 is slid to the position as in Fig. 7 to feed the liquefied fuel gas from the metering chamber 38 to the carburetor 10. The vaporized fuel is sprayed through the nozzle 39 to fill the combustion chamber 7 with the combustible mixture of the air and the fuel gas.

Then, the ignition plug 18 is discharged by the ignition controller 16 to ignite the fuel-air mixture. The combustion gas expands by the combustion in the combustion chamber 7a, and combustible gas that is not burnt yet is forced to flow through the openings 44 of respective lattices 15a-15c, i.e., the combustible gas in the combustion chamber 7a flowing into the combustion chamber 7b and the combustible gas in the combustion chamber 7b flowing into the combustion chamber 7c, thus the combustible gas successively flowing toward the piston 3.

At that time, the lattices **15** are an obstacle to the combustible gas flowing through opening **44**, and it generates a vortex flow downstream respective lattices **15**, i.e. it results in a turbulent flow.

The flame in the combustion chamber **7a** is a laminar flow premixed flame of a low combustion speed, but, after the flame propagated and passed through the openings **44a** of the lattice **15a**, the flame in the combustion chamber **7b** becomes a turbulent flow premixed flame owing to the turbulence and the combustion speed increases. The increase of combustion speed causes the combustible gas flowing from the combustion chamber **7b** to the combustion chamber **7c** to increase its flow rate, and the vortex flow generated downstream the lattice **15b** is further strengthened, i.e. it results in a stronger turbulent flow. When the flame propagates to the combustion chamber **7c** owing to the stronger turbulent flow, the combustion speed further increases.

In this manner, the combustion speed rises every time the flame passes through lattices **15**, and the inside of the housing **1** becomes under a high pressure in a moment. This pressure drives the piston **3** from the position of piston stopper **26** toward the guide **4** against the force of the elasticity of O-ring **14** to reach a driving stroke, as shown in Fig. **2**. In the driving stroke, a nail is driven

and the air in the space of the piston 3 on the side of guide 4 is compressed to flow into the pressure accumulating chamber 8 through the pressure accumulating valve 21 to be accumulated there. At this time point, the inlet port 12 is closed by the inlet valve 22.

The compressing driving stroke terminates when the piston 3 collided against the piston damper 27, and the shock of collision with the piston 3 is attenuated by the piston damper 27. The combustion reaction of the fuel filled in the combustion chamber 7 completes, and the increase of temperature and pressure in the combustion chamber 7 ends. When the pressure in the cylinder 2 increased and the force toward the guide 4 caused the control sleeve 45 of the pressure detecting chamber 28 to make the cylinder 2 slide toward the guide 4 against the force of cylinder spring 29, the pressure reducing path 43 is opened and the high-temperature and high-pressure gas in the combustion chamber 7 is released to the atmospheric air through the pressure reducing valve 23, resulting in the decrease of temperature and pressure in the cylinder 2.

The pressure reduction in the pressure detecting chamber 28 causes the cylinder 2 to return to the original position by the restoring force of piston spring 29 until the cylinder 2 come in contact with the cylinder damper 19, and thereby the pressure reducing path 43 is closed again

and the combustion chamber 7 is also closed.

After the collision with the piston damper 27, the piston 3 turns to a return stroke toward the lattices 15. The pressure in the space above the piston 3 is lowered by the release of combustion gas to form a vacuum. The atmospheric air is drawn into the space under the piston 3 through the inlet valve 22, causing the piston 3 to slide toward the lattices 15 by the pressure difference between those spaces, but the sliding motion toward the lattices 15 is limited by the cylinder damper 19, and the piston 3 returns to the position of piston stopper 26 owing to the elasticity of O-ring 14. During this time period, the pressure accumulating chamber 8 is closed by the pressure accumulating valve 21.

Then, the vent sleeve 20 is slid to the position as shown in Fig. 5 to cause the passage 33 to communicate with the scavenging port 25 with keeping the exhaust port 24 closed, so that the atmospheric air is drawn into the combustion chamber 7 because of the vacuum in the combustion chamber 7. Then, the vent sleeve 20 is further slid to the position as shown in Fig. 3 to open the exhaust port 24 and feed the accumulated gas in the pressure accumulating chamber 8 to the combustion chamber 7 through the scavenging port 25, thereby completing the scavenging operation.

Although, in the example, a thermal element is used for detecting temperature, the thermal element may be replaced with a bimetal, which is used for a make-break contact utilizing the difference in coefficients of linear thermal expansion of two metals, for temperature detection and heating control. Furthermore, switching operation of the resistor heating circuit may be also conducted by a manual switch.

[Advantage of the invention]

According to the present invention, since the vapor pressure of fuel gas is raised by heating the fuel or fuel-air mixture, the fuel gas can be ignited without fail even under the condition of a low environmental temperature, therefore enabling the operation of internal-combustion piston driving apparatus even when the environmental temperature is low.

4. Brief Description of the drawings

Fig. 1 is a vertical sectional side view showing a nailer, which is an example of internal-combustion piston driving apparatus according to the present invention, in the state before its driving operation. Fig. 2 is a vertical sectional side view showing the nailer in the driving operation.

Figs. 3, 4 and 5 are enlarged sections showing the

relative relations among the vent sleeve, the exhaust and scavenging ports of housing and the passage, in which: Fig. 3 shows the state before driving operation; Fig. 4 shows the state gas is burnt in the combustion chamber; and Fig. 5 shows the state, after the piston completed its return stroke, the inlet port is connected with the passage with keeping the exhaust and scavenging ports of the combustion chamber closed.

Fig. 6 is a partially enlarged sectional view showing the structure of a temperature controller for heating fuel and the state a metering chamber is connected with the combustion chamber. And, Fig. 7 is a partially enlarged sectional view showing the state a metering chamber is connected with a carburetor.

In the figures,

1.....Housing; 2.....Cylinder; 3.....Piston;
7.....Combustion chamber; 9.....Fuel chamber;
16.....Ignition controller; 17.....Temperature controller;
34.....Fuel cylinder; 35.....Fuel piston;
36.....Metering cylinder; 37.....Metering bulb;
38.....Metering chamber; 40.....Thermal element;
41.....Power source; and 42.....Resistor.

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